ADAPTIVE MULTISCALE ANALYSIS OF FUNCTIONALLY GRADED MATERIALS

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The computational analysis of functionally graded materials (FGMs) poses significant challenges. Any attempt to include the details of the microstructure in the analysis leads to an unmanageable number of degrees of freedom. This has led to the use of "layered" averaging techniques. In these techniques, the FGM is first divided into a number of layers. Within each layer, a standard averaging technique – e.g., rule of mixtures, Mori-Tanaka method, etc. – is used to represent the layer as a homogeneous medium (see [1,2]). The accuracy of such an approach, of course, depends on the number of layers as well as the averaging technique used within each layer.

We present an adaptive approach to the analysis of FGMs in which the modeling error resulting from the use of averaging techniques is estimated layer-by-layer. This procedure does not require knowledge of the exact "fine-scale" solution. If the estimated modeling error in a layer exceeds a preset tolerance, the model is refined by taking into account the fine-scale microstructure in the affected layer. The error estimation procedure, the adaptive algorithm and its application to sample FGMs will be discussed.

References

[1] T. Reiter, G. J. Dvorak, and V. Tvergaard, "Micromechanical models for graded composite materials," *J. Mech. Phys. Solids*, v. 45, p. 1281–1302, 1997.

[2] J. R. Cho, D. Y. Ha, "Averaging and finite-element discretization approaches in the numerical analysis of functionally graded materials," *Materials Science and Engineering*, v. A302, p. 187–196, 2001.